

CRUISE SHIPS AND SUSTAINABILITY IN BERMUDA: A PRELIMINARY EVALUATION

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CHAPTER 1 | INTRODUCTION

1.1 BACKGROUND

In January 2006, Industrial Economics, Inc. (IEc) entered into a contract with the Bermuda National Trust (BNT) to review recent conceptual plans involving potential modifications to Bermuda's ports, harbors, and/or channels for (at least in part for cruise ship accommodation purposes) and provide a preliminary, independent assessment of cruise ship market assumptions, key environmental issues and potential implications for Bermuda's "carrying capacity." This report is the deliverable for that contract. We view this document as a preliminary evaluation intended to: a) provide an overview of key environmental and carrying-capacity issues raised by various development concepts for Bermuda's ports; b) promote stakeholder discussion of such issues early in the development process; c) identify areas in need of additional study; and d) ultimately, improve decision-making by providing stakeholders with a fuller accounting of potential costs and benefits associated with development concepts under consideration. This report is not a comprehensive, comparative analysis of the numerous port concepts that have been identified to date or a full evaluation of all potential impacts that might arise from such actions; additional information and analysis would be required to conduct such tasks.

1.2 APPROACH

To inform this preliminary evaluation, we obtained and conducted an initial review of relevant information from a variety of sources, including professional technical literature, documents produced by or for Bermuda government agencies related to the cruise industry in Bermuda (including the 2005 Cruise Ports Master Plan Update), documents related to the cruise industry and Bermuda's natural environment produced by the BNT and other non-governmental entities and individuals, and information obtained from internet and other electronic searches.

In addition to the document and information review, Mr. Michael Donlan (IEc) and Dr. Andrew Price (consultant to IEc) visited Bermuda from 5 February to 9 February 2006 and participated in meetings with representatives of several stakeholder groups, including: the Bermuda National Trust; the Corporation of St. George's; the West End Development Corporation; the Corporation of Hamilton; the Ministry of Tourism and Transport (including the Department of Marine and Ports); the Ministry of the Environment Department of Conservation Services; the Bermuda Biological Station for Research; Mr. Thad Murdoch (principle investigator for the Bermuda Reef Ecosystem Assessment and Mapping Initiative); Dr. Samia Sarkis (consultant to Ministry of the

Environment Department of Conservation Services); and Mr. Michael Phillips (tour boat operator).

During the site visit, Dr. Price and Mr. Donlan also visited several locations in Bermuda (including St. George's, Dockyard, and Hamilton) and were provided boat-based tours of the channels leading into these ports.

The remainder of this chapter provides background information underscoring the importance of early, full integration of environmental considerations into planning processes. Chapter 2 provides information and preliminary discussion of several issues related to Bermuda's cruise ship market. Chapter 3 identifies key risks from port modifications, cruise ships and associated activities to sensitive marine ecosystems. Chapter 4 discusses potential issues and implications associated with Bermuda's "carrying capacity." Chapter 5 identifies potential next steps and additional research needs.

1.3 THE ENVIRONMENT AS AN INTEGRAL PART OF DECISION-MAKING

1.3.1 WHAT IS AT STAKE: BERMUDA'S NATURAL SYSTEMS?

On 5 September, 2003 Hurricane Fabian, the worst storm to hit Bermuda in half a century, battered the island and damaged the airport causeway. This highlighted the power of natural events and the importance of the environment in providing natural defence. For this and many other reasons outlined in this report the environment should be an important factor in stakeholder decisions about different port development alternatives. The decision affects far more than the size of ships allowed into Bermuda and where they go. It is also about far more than the amount of money spent in Bermuda by visitors.

Critical to all stakeholders is understanding what various cruise ship options mean for the diverse services provided by Bermuda's natural environment; enjoyment of its beauty and recreational opportunities; the protections it offers; and the ability of Bermudian people to move around the island. The degree to which port development options affect the coast also matters in other ways, for a physically hazardous environment is less conducive to international business and investment than a physically secure one. Also at stake is the environmental legacy left by port development and the potential expansion of the cruise ship industry for future generations of Bermudians.

Environmental implications can vary among cruise ship alternatives. This applies not only to ships, ports and supporting shore facilities, but also activities needed for navigation and safe passage (e.g. widening of channels and dredging) and passenger transport once cruise ships have arrived. Impacts can be substantial and long-lived. Following the grounding of the cruise ship 'Mari Boeing' off Bermuda in 1978, for

example, few corals survived the accident.¹ Moreover, long-term monitoring of the grounding scar has shown reef recovery to take around 100 years (Anderson et al., 2001).

There is now growing realisation that integrating environmental issues into the development planning process is more effective than treating the environment as a separate sector and/or issue to be addressed after critical planning decisions have been made.² The following sections highlight the importance of some of Bermuda's major coastal and marine ecosystems, all of which could potentially be affected (positively or negatively) by different cruise ship alternatives. These sections are not intended to exhaustively document all potential resource impacts, but provide general background context.

(a) Coral reefs

Coral reefs are best known for the biodiversity and fishery resources they generate. They function as solar-powered (photosynthetic) coastal food factories. Although Bermuda's reefs are marginal, they do support grouper and snapper fisheries; the pot fishing industry alone was valued at \$2 million annually in 1990 (Bryant et al., 1998).³ Besides their biological services, reefs provide natural physical protection. In physical terms, for example, an extensive reef (like Bermuda's outer reef system) acts as a 'self-repairing' breakwater.

Although robust against minor and even moderate disturbances, recovery of reefs from ship groundings, hurricanes and other major mechanical damage can take decades. Impacts from siltation, sewage and other contaminants (Jones, 2005) may seem less serious yet these stressors can, paradoxically, be more harmful to coral reefs. Of real concern is when reefs switch from a living, renewable resource to a physical non-renewable one, i.e. bare substrate. Without accretion from calcification by corals, sooner or later the reefs will begin to erode and lose their natural defence capacity.

(b) Other critical habitats

Mangroves are another critical marine habitat in Bermuda. Like coral reefs, they are the most northerly example in the world, and both have relatively low species diversity. Only the Red and Black Mangroves are represented. Mangrove habitat is important as a nursery for juvenile reef fish, as well as several bird species (Anderson et al., 2001). It is

¹ See website:

http://72.14.207.104/search?q=cache:AP3PhtwSXFUJ:www.bbsr.edu/currents_fall01.pdf+mari+b+oeing+grounding&hl=en&gl=uk&ct=clnk&cd=2

² EIAs, for example, are often made after a development option has been decided upon – essentially as a 'damage limitation' exercise. Hence, it is often reactive. In contrast, integrated coastal planning attempts to address environmental issues proactively, as discussed later in the report.

³ Coral coverage (~50%), growth and biodiversity are relatively low, as Bermuda's reefs are high-latitude reefs, in fact the most northerly reefs in world. For example, they harbour about one-third of the shallow-water coral species documented for Jamaica (cited in Anderson et al., 2001).

an important transition zone between land and sea. Mangroves are particularly valuable for their role in absorbing nutrients (e.g. from terrestrial sources), which are highly damaging to reefs. Their role in physical protection, against storms, and in stabilising the substrate may be as or more important as their biological functions. As a result of development pressures in Bermuda their total area has declined from around 25 ha (pre-settlement times) to their current area of 18 ha made up of some 30 swamps (Anderson et al., 2001). The extent to which mangrove areas might be threatened by cruise ship developments has not been fully determined.

Seagrass beds perform many of the same functions as mangroves. Four species are represented in Bermuda (Anderson et al., 2001). With notable exceptions (e.g. Green turtles) few animals consume seagrass directly. Most species utilise it only after it enters detrital pathways via the microbial loop. A recent survey at three sites revealed 44 species of fish, excluding gobies (see Anderson et al., 2001). Extensive biophysical interactions are known to occur between coral reefs, seagrasses and mangroves. Impacts to one system can also adversely affect another, together with their associated species.⁴

(c) Biodiversity hotspot areas

Several studies have documented the biodiversity of Bermuda, in terms of species and habitats (Anderson et al., 2001). Of the 8,301 species known, more than 50% are marine (Sterrer, 1998). Knowledge of the locations of biodiversity ‘hotspots’ will be valuable to help determine threats from the different cruise ship alternatives. This will need to be obtained from various sources, including maps of important seagrass and coral reef areas as well as other key habitats; information/maps on locations of high species richness and endemism/rarity; and sites where birds, turtles and other species of conservation importance nest or reside during critical life cycle phases. Valuable summary information is available in *Bermuda Biodiversity Country Study* (Anderson et al., 2001) and *Bermuda National Biodiversity Strategy and Action Plan* (BSAP), 2003.

(d) Key fishery areas

Bermudian sea food species and their fisheries are a significant resource.⁵ Spawning and nursery areas are vulnerable to both over-harvesting and environmental impacts from development activities. Species that aggregate to spawn (e.g. Grouper) are at particular risk, if spawning areas happen to coincide with areas disturbed by cruise ships (and other environmental impacts). Mapping of the distribution of spawning, nursery and fishing areas of important fish species will help determine which areas might be at greatest risk

⁴ Mangroves, seagrasses and coral reefs are often critical to species of commercial and conservation interest at particular phases of their life cycle.

⁵ Capture fisheries grossed \$6 million/y in 1988 and \$6.5 million in 1998, despite closure trap fishery in 1990 (Anderson et al., 2001).

from the different cruise ship alternatives.⁶ Shallow embayments and certain coral areas may be important spawning sites grouper and possibly other species.

1.3.2 LESSONS FROM ELSEWHERE

The devastation caused by Hurricane Katrina (2005) and the earlier tsunami in Indonesia (2004) dramatically highlighted the importance the environment in providing natural defence. These and other examples (e.g. in Maldives) provide vivid, easily recognizable examples of the types of adverse effects that can arise from insufficiently restrained development. While Bermuda in many ways has unique resources and a distinctive environmental setting, the issues arising from tourism and other development pressures share features in common with the situation in other parts of the world.

The Maldives provides a graphic illustration of the role of coral reefs in natural defence. The country's continued physical and economic existence depends on the underlying reef platform. Extensive coastal infilling and reclamation occurred around the capital, Malé, which is now almost square (Exhibit 1-1). This greatly impaired the natural protective capacity of the reefs, resulting in the need for an artificial breakwater on the south of the island (right of photo) for protection against flooding events. This high technology solution, costing US\$12 million, or US\$8,000 per linear metre, would not have been necessary had the possibility of adverse environmental impacts been considered (Price & Clark, 2000).

Coral reefs are not the only ecosystems that are important for coastal defence (and which potentially could be threatened by cruise shipping alternatives in Bermuda.) In Sri Lanka, for example, tsunami related deaths and damage were partially alleviated by mangroves and probably also by reefs (see Baird et al., 2005; Dahdouh-Guebas et al., 2005; Fernando et al., 2005; Kathiresan & Rajendran, 2005). However, mangroves' protective role (Exhibit 1-2) would have been greater had these ecosystems not been severely degraded by past unsustainable development practices.

The general lesson from these vivid examples is that potential alterations to the natural environment (e.g., modifications to harbor openings, navigational channel widening and/or deepening, and similar actions) as well as changes in human use of these resources (e.g., passenger transport while in Bermuda and/or use of cruise ships with different characteristics/risk profiles) need to be examined carefully for a range of potential risks (and benefits) to Bermuda's flora and fauna, coastal property and infrastructure, and human health. Better development decisions can be made by stakeholders informed of the full range of potential risks and rewards associated with different proposals.

⁶ It is understood that juvenile fish mostly occupy the inner reefs, suggesting this habitat has an important nursery function. At present these habitats are probably most vulnerable to sedimentation impact from cruise ships. An estimated 30-40 common species of fish are associated with shallow, inner reefs, compared with 10-14 common species amongst the deeper, outer reefs (personal communication, Bermuda Biol. Res. Station).

1.3.3 OTHER CONSIDERATIONS

(a) National and regional environmental setting

Other factors that should be considered by stakeholders include the extent and magnitude of past and ongoing environmental pressures. In general, recovery from a future impact is likely to be quicker if the environment is pristine than in an environment that is already heavily perturbed.⁷

Bermuda's outer reefs are generally in excellent condition, the greatest threat to them coming from siltation or sedimentation (Knapp et al., 2000; Anderson et al., 2001).⁸ However, some inshore and coastal areas have experienced serious destruction of seagrasses, mangroves and coral reefs. For example, 10 species of fish recorded around Castle Harbour were no longer observed following creation of the airbase in the 1940s (Anderson et al., 2001). St George's Bay is example of an area that has been degraded for 300 years. In Hamilton environmental contamination may be even greater.

The regional environmental setting is also important. In the wider Caribbean, for example, hard coral cover declined by 80%, from about 50% to 10% cover over three decades (Gardner et al., 2003). This finding was based on data from 263 sites, including Bermuda & Bahamas.⁹ Effects of coral bleaching, commonly associated with increasing sea temperatures, have been minimal in Bermuda. Compared to other parts of the Caribbean, there has been very little coral death and fairly rapid recovery. On the other hand, at least three different coral diseases can be observed on Bermuda's reefs (Anderson et al., 2001).

Overall the wider Caribbean, including Bermuda, is quite heavily disturbed, especially if coastal and terrestrial environments are considered. Rising sea levels are also of concern, particularly to low-lying islands such as Bermuda.¹⁰ It is within this national and regional context that effects from various development options should be evaluated.

(b) Environmental commitments

Bermuda has a considerable body of national environmental legislation (Anderson, 2001). In addition, it is party to major regional and global treaties and conventions. Hence, the environment should not be viewed as a luxury, as it is the basis of contractually binding obligations. Particularly significant is the recent Environment Charter for the UK

⁷ However, some acclimation or adaptation may be possible in environments constantly or repeatedly subjected to perturbations.

⁸ Anderson et al. (2001) point out that a recent assessment (Bryant et al., 1998) rank Bermuda's reefs in the 'high risk' category. This seems to reflect: i) Bermuda's high population density, within 20 km of the coral reefs and ii) heavy shipping traffic, heavy pollution threats and other accidents.

⁹ As noted, however, Bermuda's coral reefs are generally in good condition, apart from certain coastal/inshore areas.

¹⁰ Relative sea level (RSL) rose at Bermuda at a rate of 0.67 mm/y 1955 to 1998, and at a rate three times larger based on records for 1933-98 (Douglas & Peltier, 2002).

Overseas Territories. The eleven obligations of Bermuda set forth are explicit and clear-cut. For example, item 3 states that the government of Bermuda will: ‘ensure that the environmental considerations are integrated within social and economic planning processes; promote sustainable patterns of production and consumption within the territory’. Equally important is item 4: ‘undertake environmental impact assessments before approving major projects and while developing our growth management strategy’.

(c) Safeguarding protected areas as insurance against uncertainty

As part of its conservation efforts Bermuda has several categories of protected areas on land, the coast and in the marine environment. On land, some 500 ha (9% of the land area) is set aside as nature reserves and parks (Anderson et al., 2001).¹¹ In Bermuda’s coastal and marine environment there are 29 protected areas, two coral reef preserves, two seasonally protected areas (from fishing) and one Marine Park, the Walsingham Marine Reserve (Anderson et al., 2001). In addition, St. George’s and its associated fortifications became a World Heritage Site by UNESCO in 2000. This port is also one site that may be expanded under some development alternatives.

Bermuda’s protected ways provide opportunities for recreation, research, enjoyment and, importantly, they promote conservation. Linked to the conservation role, protected areas also afford some insurance against future uncertainty, both from natural events (e.g. hurricanes) and development pressures (e.g. tourism activities). Some of the likely environmental impacts associated with different development alternatives are discussed below. However, experiences elsewhere have shown that predictions about development options and associated activities often carry considerable imprecision and uncertainty.

Upholding protected area regulations, and other environmental legislation, is therefore critical. Maintenance of environmental robustness, particularly Bermuda’s outer reef but also other critical natural systems, should be a central and integral part of any port development plan.

¹¹ Seven different terrestrial conservation/protected area designations, each with its own management objectives, are recognised (Anderson et al., 2001). Similarly, the various categories of marine protected areas also have different management aims.

EXHIBIT 1-1. AERIAL PHOTO OF MALÉ, THE CAPITAL OF THE MALDIVES, SHOWING THE ARTIFICIAL BREAKWATER TO THE SOUTH OF THE ISLAND (RIGHT OF PICTURE; IMAGE FROM [NEWS.NATIONALGEOGRAPHIC.COM/.../MALDIVES.JPG](https://news.nationalgeographic.com/.../maldives.jpg).)



EXHIBIT 1-2. A).THE 2004 TSUNAMI KILLED MORE THAN A QUARTER OF A MILLION AND DAMAGED HUMAN ASSETS, TERRESTRIAL AND MARINE WILDLIFE (IMAGES: ANDREW PRICE); B) NATURAL COASTAL DEFENCE PROVIDED BY MANGROVES IN SRI LANKA (IMAGE: DAHDOUH-GUEBAS ET AL., 2005).

A



C



B



CHAPTER 2 | BERMUDA CRUISE SHIP MARKET CONSIDERATIONS

2.1 PRELIMINARY FINDINGS

This chapter provides information about the Bermuda cruise ship market and a preliminary discussion of related trends, issues and implications for the future. Summary findings are presented below.

- The ships most frequently calling on Bermuda originate from the Northeast and Mid-Atlantic coasts of the US, likely reflecting the relative proximity of Bermuda compared to other potential island destinations. Common ports of origin include Cape Liberty (NJ), New York, Philadelphia, Boston, and Baltimore. For most of these cruises, Bermuda is the sole destination and the cruise duration is generally seven nights.
- The majority of Bermuda cruise trips currently take place on relatively small cruise ships (i.e., length and beam less than 692 feet and 100 feet, respectively). The four relatively small cruise ships responsible for the majority of visits to Bermuda entered into service between 1988 and 1992 and were refurbished between 1999 and 2004. However, Norwegian Cruise Lines has publicly announced an intention to transfer two of these four ships (the Norwegian Majesty and Norwegian Crown) to Asia by 2010.
- Larger ships, including post-Panamax vessels, already are calling on Bermuda.¹² For example, in 2006 Explorer of the Seas (post-Panamax) is scheduled to call on Dockyard Tuesday and Wednesday of every other week during the May through October period. The Costa Magica (post-Panamax) is scheduled to call on Hamilton twice during the 2006 cruise season.¹³ While the environmental impacts and risks associated with both large and small ships need further study (see Chapters 4 and 5), two of Bermuda's three ports already are physically capable of accommodating ships substantially larger than the most frequent "current callers" on Bermuda.¹⁴

¹² Post-Panamax ships are too big to transit the Panama canal. The Panama Canal Authority indicates that the maximum ship dimensions for Panama Canal transit are a length of 965 feet, a beam (width) of 106 feet, a draft of 39.5 feet (in tropical fresh water), and a height of 190 feet (waterline to vessel's highest point), although exceptions are allowed in certain circumstances.

¹³ Itinerary information obtained from www.destinationoceans.com, accessed 31 March 2006.

¹⁴ It is our understanding that Hamilton is constrained to ships less than 715 feet in length when two cruise ships are in port. However, it is unclear what size constraints exist if only one cruise ship were scheduled to be in Hamilton, as appears to be the case with the Costa Magica (scheduled

- Industry observers generally classify cruise lines into "luxury", "premium", "contemporary" and "niche" categories. In 2005, one "luxury" ship (the Seven Seas Navigator) called on Bermuda nine times. In 2006, that ship is scheduled for one Bermuda visit, in April. The remainder of its 2006 April through October cruise schedule involves European destinations. No "niche" ships currently call on Bermuda. The majority of Bermuda cruise visits are classified as "contemporary", a smaller but significant number are classified as "premium" and a handful are considered "luxury" cruises.
- While future predictions are inherently uncertain, publicly available information raises questions about claims that the cruise industry will abandon Bermuda in the next several years unless significant changes are made to Bermuda's ports. First, while consumer preferences can change, there is substantial market demand for Bermuda cruises. Bermuda is substantially closer to the northeastern US ports it primarily serves than other island destinations, and more than 100,000 passengers currently cruise to Bermuda from these locations each year. The relatively small cruise ships responsible for the majority of current visits are middle-aged, but all four have been refurbished within the last two to seven years. Bermuda cruise passengers have a demonstrated willingness to travel on smaller, middle-aged ships (perhaps reflecting the substantial on-island time generally associated with Bermuda cruises relative to itineraries of similar duration to more distant island destinations). While specific ships serving Bermuda will change over time, there is recent precedent for replacement with relatively small ships (e.g., the 2006 replacement of Horizon with Empress of the Seas).
- Publicly announced new ship builds through 2009 indicate that very few, if any, will be of comparable size to the relatively small ships responsible for most Bermuda cruise visits. However, as noted above, two of Bermuda's ports already are capable of accepting larger cruise ships. As an example, the post-Panamax Explorer of the Seas (calling on Dockyard in 2006) and the post-Panamax Costa Magica (calling on Hamilton in 2006) have combined capacities totaling approximately 8,000 passengers and crew. If even a single relatively small cruise ship (capacities typically between 1,500 and 2,000 passengers and crew) continued calling on St. George's, it appears that a daily capacity approaching or equal to the existing limit of 10,000 passengers and crew potentially could be reached without infrastructure changes.¹⁵
- Clearly, the ability to accommodate larger cruise ships provides Bermuda with flexibility in dealing with the cruise ship industry over coming decades, particularly given its historical reliance on ships smaller than most of the cruise

to be in Hamilton for parts of Sunday and Monday during each of its two 2006 visits, departing before the smaller Panamax cruise ships arrive).

¹⁵ We include crew, not just passengers, in these figures under the assumption that cruise ship crew also make use of Bermuda's resources. It may be appropriate to adjust these figures downward to reflect the number of crew members are required to stay on board the ship at any given time, but such information was not readily available at the time this document was prepared.

fleet. However, with Dockyard and Hamilton already capable of accepting post-Panamax ships, it appears that there already is sufficient flexibility to maintain the cruise industry in Bermuda for many years to come.

- In our view, the real issue is finding common ground among stakeholders regarding a future vision for Bermuda and the cruise industry's place in it. Do stakeholders want to expand, reduce or maintain the cruise presence? Do they want to try to attract a different type of cruise passenger? How does the cruise industry strategy mesh with strategies to appeal to air-based tourism and increasing numbers of business travelers? Different proposals may distribute benefits and costs unequally among stakeholders within Bermuda; can these distributional issues be resolved? The answers to these questions will drive the need (if any) for infrastructure changes and/or other actions. While there is a tendency to focus on associated economic issues, **it is critical that stakeholders be provided with objective information early in the process concerning potential environmental and social costs associated with existing cruise ship deployments and proposals for new development. Potential environmental and social consequences are likely to vary among alternative plans, and can be severe and long-lived.** These issues are discussed in more detail in Chapters 3 and 4 of this report.

2.2 CHARACTERISTICS OF CRUISE SHIPS CURRENTLY CALLING ON BERMUDA

Bermuda's cruise ship season typically begins in April and ends in October. As shown in Exhibit 2-1, readily available information indicates that 23 different cruise ships called on Bermuda in 2005, including one post-Panamax ship (Royal Caribbean's Voyager of the Seas). However, many ships were occasional callers. Six ships (see Exhibit 2-2) accounted for approximately 80 percent of the 165 visits in 2005.

As indicated in Exhibit 2-2, the ships most frequently calling on Bermuda originate from the Northeast and Mid-Atlantic coasts of the US. Common ports of origin include Cape Liberty (NJ), New York, Philadelphia, Boston, and Baltimore. For most of these cruises, Bermuda is the sole destination, the cruise duration is generally seven nights, and the cruise is a round trip.

Four relatively small cruise ships (the Zenith, Norwegian Crown, Norwegian Majesty and Empress of the Seas) will each visit Bermuda 26 times during the 2006 season. These four ships have capacities of up to roughly 2,000 people (passengers and crew); are less than 692 feet in length, 100 feet across the beam and 50,000 gross tons; and were entered into service between 1988 and 1992. As indicated in Exhibit 2-3, all four have been refurbished in recent years (1999 for the Zenith and Norwegian Majesty, 2000 for the Norwegian Crown and 2004 for the Empress of the Seas). Although publicly available information on the cost of these refurbishments is limited, such costs can be substantial (e.g., \$53.3 million spent on the Norwegian Majesty refurbishment).

In 2005, a post-Panamax ship (the Voyager of the Seas) initiated regular calls (14 trips in 2005) on Bermuda (Dockyard). In 2006, Dockyard is scheduled to receive 13 visits from

the post-Panamax ship Explorer of the Seas. These two sister ships have capacities of up to approximately 4,300 people (passengers and crew); are 1,020 feet in length, 158 feet across the beam and 138,000 gross tons; and were entered into service in 1999 and 2000. Hamilton will receive two visits from the ship Costa Magica (890 feet in length, 124 feet across the beam, 105,000 gross tons and entered into service in 2005).

Industry observers generally classify cruise lines into Luxury, Premium, Contemporary and Niche categories. Although descriptions of these categories and cruise line classifications can vary, brief summaries are provided below.¹⁶

- Luxury - "Luxury Lines offer the highest level of service and onboard environment. An exclusive air will surround your onboard experience on a luxury cruise line. Ships sizes will be anywhere from small (100 guests) to mid-sized ships (1000 guests). Cruise rates range from \$400 to \$1000 per person per day. Luxury Cruises include Crystal Cruises, [Regent] Seven Seas Cruises, Seabourn Cruise Line, and Silversea Cruises."
- Premium - "Premium Lines will contain everything that a Contemporary line would offer but in addition will have features for discerning guests as well. Better service, larger staterooms, and gourmet cuisine will set apart this style of cruise line. Cruise ships will be anywhere from mid-sized to large (500 to 1500+ guests). Cruise rates range from \$175 to \$400 per person per day. Premium Cruises include Celebrity Cruises, Cunard Cruises, Holland American Line, Princess Lines, and Oceania Cruises."
- Contemporary - "Contemporary represents a "floating resort" type of cruise. The ship will be mid-sized to large and contains the newer "mega" ships that can house thousands of guests. Value-packed, activity rich, and personal choice are three components of these vacations that really stand out. Cruise rates range from \$150 to \$350 person per day. Resort/Contemporary lines include Carnival Cruise Lines, Costa Cruise Line, Disney Cruise Line, Norwegian Cruise Line, and Royal Caribbean International."
- Niche - "Niche & Specialty Cruises focus on a specific type of cruise or destination. They might focus on one area such as Alaska. They might provide adventure-rich opportunities and give you much more immersion into your destination whether it is with cultural events, cuisine, or lectures and classes. Accommodations and amenities vary. Cruise fares range from \$200 to \$400 per person per day. Niche & Specialty Cruise lines include CruiseWest, Orient Lines, Star Clippers, Viking River Cruises, Windjammer Cruises and Windstar Cruises."

The four smaller cruise ships that will visit Bermuda most frequently in 2006 are owned by three different cruise lines: Norwegian Cruise Lines (Norwegian Crown and Norwegian Majesty); Celebrity (Zenith); and Royal Caribbean (Empress of the Seas). The

¹⁶ Category descriptions provided below were obtained from www.comparecruises.com, accessed 20 March 2006.

post-Panamax ship Voyager of the Seas that will visit Dockyard in 2006 is owned by Royal Caribbean. While Celebrity is considered a "premium" cruise line, as noted above Norwegian Cruise Lines and Royal Caribbean are considered "contemporary" lines. None of these frequent visitors to Bermuda are classified in the "luxury" or "niche" categories.

In 2005, one "luxury" ship (the Seven Seas Navigator) called on Bermuda nine times. In 2006, that ship is scheduled for one Bermuda visit. The remainder of its 2006 April through October cruise schedule involves European destinations. Four other "luxury" ships each made a single Bermuda call in 2005. Four "premium" ships (in addition to the Zenith) each made one or two Bermuda calls in 2005. None of the 165 cruise calls in 2005 were from "niche" cruise ships.

2.3 ADDITIONAL MARKET FACTORS

Predicting future cruise line deployments to Bermuda is difficult, for many reasons. Regional (and global) factors, including changing economic conditions, terrorism incidents, disease outbreaks/concern, and similar issues can substantially affect demand for cruises generally and for specific destinations in particular. Changes in competitive dynamics with air-based tourism may be important, particularly given the expected May 2006 introduction of twice-daily nonstop discount airline service (JetBlue) between New York City (JFK) and Bermuda. Within the cruise industry three different companies currently provide most of Bermuda's cruise capacity. How they (and other competitors) respond to future conditions will reflect a variety of confidential strategic and financial considerations.

Despite these uncertainties, there are reasons to be skeptical of claims that the cruise industry will abandon Bermuda in the next several years unless substantial port, harbor and/or channel changes are immediately made to accommodate the largest of the large cruise ships.

2.3.1 GEOGRAPHY

For people living in or near the Northeast region of the US, Bermuda offers an island cruise destination that can be completed in approximately one week and includes several consecutive days/nights of time on island. For example, beginning April 22 of this year, the Zenith will make weekly cruises from Bayonne, New Jersey to Bermuda. Departures are scheduled for 4:30 pm every Saturday between April 22 to October 14. The ship arrives in Bermuda at 9am on Monday, and departs for New Jersey at 3pm on Thursday, arriving at 8am on Saturday.

Brief review of 2006 cruise itineraries leaving from Boston, Brooklyn, Philadelphia and Bayonne suggests that cruise vacationers seeking other island destinations from Northeastern US ports during the April to October period generally need to commit to more time on the ship or trips longer than one week. As shown in Exhibit 2-4, differences in distance contribute to this circumstance. For example, New York City to Hamilton, Bermuda is approximately 700 nautical miles (one-way), roughly 160 nautical miles less (one-way) than a trip from New York City to Nassau, Bahamas. In comparison to a typical Bermuda itinerary, the Norwegian Spirit offers a Sunday-to-Sunday New York to

Bahamas itinerary, which includes more ocean time and a series of day visits: Tuesday in Orlando (9am-8pm); Wednesday in Miami (9am-6pm); Thursday in Bahamas destination Great Stirrup Cay (8am-6pm); and a brief Friday stop in Bahamas destination Nassau (7am-1pm).

While cruise demand segments and preferences can change, more than 100,000 passengers currently purchase one week Bermuda cruises from northeastern US embarkation points each year that include several consecutive days on island. With limited island destination alternatives that can offer a similar mix of at-sea and island time within a one week vacation from these ports, Bermuda is geographically advantaged with respect to this market segment.

Describing Bermuda, one internet cruise website states that “there are some unique aspects of a Bermuda cruise that differ from the norm. A land vacation to Bermuda is expensive, so many choose a cruise as a less expensive alternative and with ships docked overnight in port, use the ship as if it were their ‘hotel’. During your days/nights docked in Bermuda, entertainment on board is at a minimum. Due to Bermudian laws, cruise ships are strictly regulated as to music on deck, casino operation and presentation of shows. Many of the usual activities enjoyed on board ship, are not provided on a Bermuda cruise. The **destination** is the reason one takes a Bermuda cruise.”¹⁷

2.3.2 CRUISE SHIP NEW BUILDS VS. REFURBISHMENT

Exhibit 2-5 lists announced new builds through 2009. It is clear that most of the new ships to be delivered over the next few years are substantially bigger than many of the cruise ships currently serving Bermuda. However, as indicated in Exhibit 2-3, all four of the small/mid-size cruise ships currently responsible for the majority of visits to Bermuda entered into service between 1988 and 1992 and were refurbished between 1999 and 2004. Commenting on this trend, one popular website focused on the cruise industry noted that “This year [2005] has been big for Europe (it’s the new Caribbean in terms of popularity among all types of cruise travelers, from families to romance-seekers), and, rather than send ‘em out to pasture, mid-sized, middle-aged ships -- from Royal Caribbean’s Enchantment of the Seas to Holland America’s Ryndam -- have received the cruise equivalent of a hit of Viagra.”¹⁸

Norwegian Cruise Lines has publicly announced that an intention to transfer all six of its mid-size, middle-aged ships to parent company Star Cruises by 2010 for transfer to Asian markets.¹⁹ Two of the four relatively small cruise ships with weekly calls to Bermuda are owned by Norwegian Cruise Lines. While specific ships serving Bermuda undoubtedly will change over time, there is recent precedent for replacement with relatively small ships (e.g., the 2006 replacement of Horizon with Empress of the Seas).

2.3.3 CURRENT SIZE LIMITATIONS FOR CRUISE SHIPS CALLING ON BERMUDA

¹⁷ Obtained from <http://www.bermudaportreviews.com> accessed 3 January 2006.

¹⁸ Obtained from <http://www.cruisecritic.com/features/articles.cfm?ID=230> accessed 21 March 2006.

¹⁹ See, for example, NCL press releases on 16 July 2004 and 17 December 2004.

Bermuda's three ports (St. George's, Hamilton and Dockyard) vary significantly with respect to cruise ship size limits. While approvals to call on specific ports are made on a ship-specific basis (reflecting ship-specific characteristics that can affect navigational safety), St. George's clearly is the most constrained. Penno's Wharf, the larger of St. George's two cruise berths, is approximately 750 feet long. Vessels with up to 26 feet of draft are permitted to transit Town Cut Channel. The largest current, regular cruise ship caller on St. George's is Empress of the Seas, which has a length of 692 feet, a beam of 100 feet and a tonnage of 48,563 gross tons.

Hamilton's port is less constrained than St. George's, but more so than Dockyard. As noted above, the post-Panamax Costa Magica (length 890 feet, beam 124 feet, and tonnage of 105,000 gross tons) is expected to call on Hamilton twice during the 2006 cruise season. Dockyard currently accepts even larger ships. The Explorer of the Seas, for example, has a length of 1,020 feet, a beam of 158 feet and a tonnage of 138,000 gross tons. While the environmental impacts and risks associated with these (and smaller) ships need further study (see Chapters 3, 4 and 5), it is clear that two of Bermuda's three ports already can physically accommodate post-Panamax ships.

2.3.4 LUXURY AND NICHE CRUISE LINES

As noted above, most current cruises to Bermuda are classified in the "contemporary" category. Detailed evaluation of the potential for attracting more "premium", "luxury", and/or "niche" passengers is beyond the scope of this report. Nevertheless, it is clear that substantial challenges exist. For example, a brief review of itineraries for four luxury ships that each have scheduled a single visit to Bermuda in 2006 indicate that almost all of their April to October cruises are to European, Eastern Mediterranean, or Alaskan destinations. Their brief visits to Bermuda tend to take place during repositioning cruises. Thus, additional Bermuda trips could not be added without significant changes to their current itineraries.

No "niche" cruise lines were represented in the 165 cruise trips to Bermuda taken in 2005. In general, "niche" cruise ships are small, with passenger capacities of a few hundred or less. Whether due to Bermuda's relative geographic isolation, somewhat cooler winter temperatures, the desirability of its attractions compared to other destinations, cost and/or other factors, "niche" cruise lines appear to focus on other regions during the Bermuda cruise season. For example, with the exception of a single cruise to Barbados in April, "niche" cruise line Windstar does not offer North American, South American or Caribbean itineraries during the April to October period. CruiseWest offers only a small number of Panama/Costa Rica itineraries during this period. Star Clippers offers Caribbean cruises, but only from November through April. While unreasonable to rule out the possibility of establishing "niche" itineraries involving Bermuda, clearly substantial challenges exist.

EXHIBIT 2-1 BERMUDA CRUISE SHIPS CALLS IN 2005

SHIP NAME	DATE ENTERED SERVICE	PASSENGER CAPACITY	CREW CAPACITY	DIMENSIONS			BERMUDA PORT CALLS IN 2005
				LENGTH (FT)	BEAM (FT)	TONNAGE (GT)	
Century	1995	1,750	858	815	105	70,606	1
Constellation	2002	1,950	950	965	105	91,000	2
Crystal Serenity	2003	1,080	655	820	106	68,000	1
Discovery	1972	750	315	553	80	20,216	1
Empress of the Seas*	1990	2,020	685	692	100	48,563	0
Explorer of the Seas**	2000	3,114	1,176	1,020	158	138,000	0
Grand Princess	1998	2,600	1,100	951	118	108,806	2
Grandeur of the Seas	1996	2,446	760	916	106	74,000	14
Horizon	1990	1,354	645	682	95	46,811	26
Jewel of the Seas	2004	2,501	842	962	105	90,090	7
Legend of the Seas	1995	2,076	720	867	105	69,130	1
Millennium	2000	1,950	999	965	105	91,000	1
Norwegian Crown	1988	1,052	525	614	92	34,250	26
Norwegian Majesty	1992	1,462	570	680	89	40,876	26
Norwegian Spirit	1998	1,966	965	880	106	77,000	1
Saga Rose	1965	587	350	620	80	24,474	1
Saga Ruby	1973	655	380	627	82	25,000	2
Seabourn Pride	1988	208	160	440	63	10,000	1
Seven Seas Mariner	2001	708	440	725	69	30,800	1
Seven Seas Navigator	2001	530	325	560	81	28,550	9
Seven Seas Voyager	2003	700	447	670	95	45,000	1
The World	2002	200	250	644	98	43,524	1
Voyager of the Seas	1999	3,114	1,176	1,020	158	138,000	14
Zenith	1992	1,374	657	682	95	47,255	26
<p>Notes:</p> <p>* Empress of the Seas will replace Horizon in 2006</p> <p>** Explorer of the Seas will replace Voyager of the Seas in 2006.</p> <p>Sources:</p> <p>Port Calls in 2005 - http://www.bermutatourism.com/cruise/pdf/2005_cruise_ship_schedule.pdf</p> <p>Ship-Specific Data - various cruise line websites</p>							

EXHIBIT 2-2 CRUISE SHIPS VISITING BERMUDA MOST FREQUENTLY IN 2005 AND 2006

SHIP NAME	DATE ENTERED SERVICE	NUMBER OF BERMUDA CALLS (2005 & 2006)	MOST RECENT REFURBISHMENT	CRUISE ORIGIN (2006)	OTHER DESTINATIONS ON CRUISES INCLUDING BERMUDA (2006)	TOTAL CRUISE DURATION (2006)
Grandeur of the Seas	1996	2005 - 14 2006 - 13	2001	1. Baltimore, MD 2. Baltimore, MD	1. -- 2. Aruba, Curacao, Cayman Islands, Mexico, St. Maarten, New Orleans	1. 6 days 2. 14 days
Horizon (2005) Empress of the Seas (2006)	1990	2005 - 26 2006 - 26	2004	Philadelphia, PA	--	8 days
Norwegian Crown	1988	2005 - 26 2006 - 27	2003	New York, NY; Philadelphia, PA.	--	5- 7 days
Norwegian Majesty	1992	2005 - 26 2006 - 27	1999	Boston, MA; Charleston, NC.	--	7 days
Voyager of the Seas (2005) Explorer of the Seas (2006)	1999 2000	2005 - 14 2006 - 13	2002 N/A	Cape Liberty, New York Harbor, NJ	--	7 days
Zenith	1992	2005 - 26 2006 - 26	1999	Cape Liberty, New York Harbor , NJ	--	8 days
<p>Note: "--" in the Other Destinations column indicates a direct round trip cruise to and from Bermuda with no additional ports of call</p> <p>Sources: Port Calls in 2005 - http://www.bermutatourism.com/cruise/pdf/2005_cruise_ship_schedule.pdf Ship-Specific Data and Port Calls in 2006 - various cruise line websites</p>						

EXHIBIT 2-3 CRUISE SHIP REFURBISHMENT

Cruise ship refurbishment can comprise interior and exterior upgrades and renovations to any portion of the ship. Below are representative interior and exterior refurbishment examples from cruise line press releases for the ships in the table below.

Interior

New restaurants and dining options, expanded entertainment including refurbished theaters, new casinos, new coffee and outdoor bars, expanded spa and gym fitness options, solarium window replacement, addition of glass walls, new upholstery, new carpets, addition of teen and children's centers, new suites and passenger staterooms, upgrades to elevators, landings, corridors, and restrooms.

Exterior

Pool deck enhancement, main wood deck restoration, new and enlarged deck space, lengthening with pre-fabricated midsection insertions, new swimming pools, hull painting (plain, and decorative).

SHIP NAME	DATE ENTERED SERVICE	MOST RECENT REFURBISHMENT	TYPE OF REFURBISHMENT	COST OF REFURBISHMENT \$ USD MILLIONS
Grandeur of the Seas	1996	2001	Interior	n/a
Empress of the Seas (replacing Horizon in 2006)	1990	2004	Interior	n/a
Norwegian Crown	1988	2000	Interior Exterior	"multi-million dollar"
Norwegian Majesty	1992	1999	Interior Exterior	53.3
Explorer of the Seas (replacing Voyager of the Seas in 2006)	2000	--	--	--
Zenith	1992	1999	Interior	n/a

SOURCES:

Norwegian Cruise Line (Norwegian Crown, Norwegian Majesty) <http://www.ncl.com/news> (Accessed 1/24/2006).

Royal Caribbean International (Grandeur of the Seas, Empress of the Seas, Voyager of the Seas, Explorer of the Seas) <http://www.royalcaribbean.com/pressroom> (Accessed 1/24/2006)

Cruise Lines International Association (Zenith) <http://www.cruising.org/cruiselines> (Accessed 1/26/2006)

EXHIBIT 2-4 DISTANCES FROM SEVERAL PORTS TO BERMUDA AND ANOTHER ISLAND DESTINATION

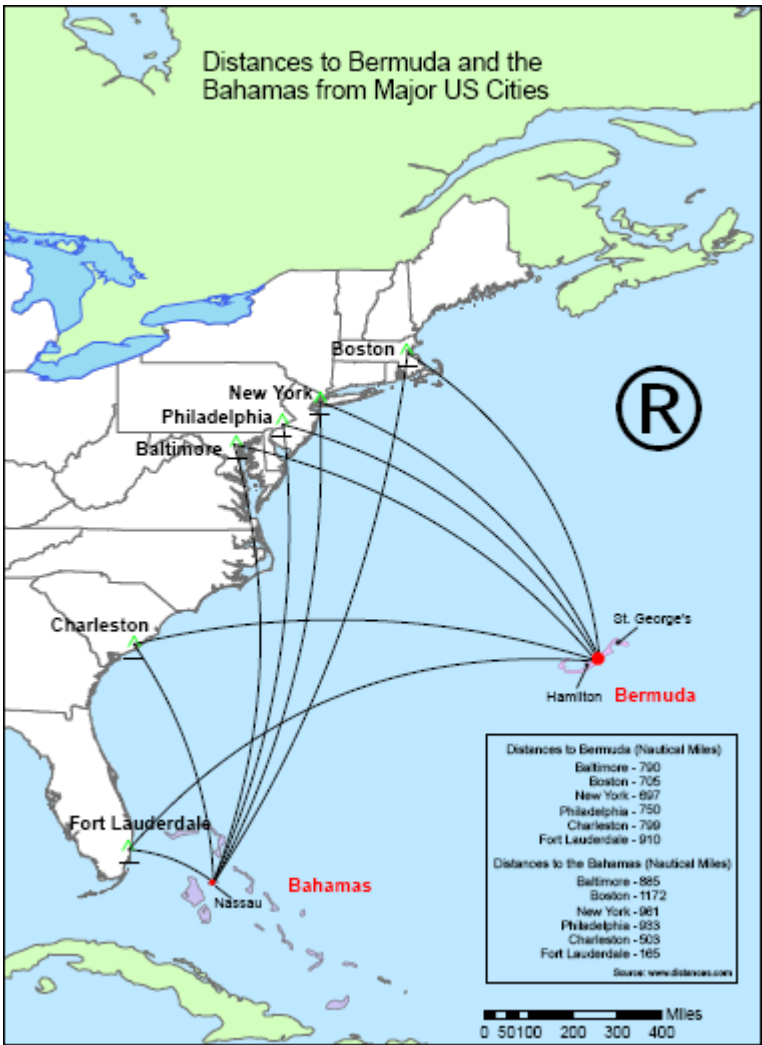


EXHIBIT 2-5 NEW CRUISE SHIP BUILDS 2005-2009

CRUISE LINE	SHIP NAME	SIZE (GT)	PASSENGERS	SHIPYARD	COST (US\$ MILLION)	DELIVERY DATE
2005						
P&O	Arcadia	85,000	1,968	Fincantieri	\$400	April
NCL America	Pride of America	81,000	1,900	Lloyd Werft	\$440	June
Carnival	Carnival Liberty	110,000	2,974	Fincantieri	\$400	Fall
NCL	Norwegian Jewel	93,000	2,400	Meyer Werft	\$395	August
2006						
Holland America	Noordam	84,000	1,800	Fincantieri	\$400	January
MSC	Musica	65,000	1,600	Chantiers de l'Atlantique	\$250	June
Royal Caribbean	Freedom of the Seas	160,000	3,600	Aker Yards	\$720	Summer
Princess	Crown Princess	116,000	3,100	Fincantieri	\$400	Summer
NCL	Pride of Hawaii	93,000	2,400	Meyer Werft	\$395	Summer
Costa	Costa Concordia	116,000	3,100	Fincantieri	\$400	Summer
2007						
Cunard	Queen Victoria	95,000	1,850	Fincantieri	\$472	January
NCL	Norwegian Pearl	93,000	2,384	Meyer Werft	\$500	February
AIDA	TBD	68,500	2,030	Meyer Werft	\$315	April
Princess	Emerald Princess	116,000	3,100	Fincantieri	\$400	Spring
Carnival	Carnival Freedom	110,000	2,974	Fincantieri	\$400	Spring
MSC	Orchestra	65,000	1,600	Chantiers de l'Atlantique	\$250	Spring
Royal Caribbean	Freedom Class	160,000	3,600	Aker Yards	\$720	Summer
Radisson	TBA	49,000	700	T. Mariotti	\$250	Summer
2008						
Carnival	TBD	110,000	3,000	Fincantieri	\$475	Spring
Princess	Canberra	116,000	3,100	Fincantieri	\$490	Spring
MSC	Fantasia	133,500	3,887	Chantiers de l'Atlantique	\$550	Spring
Royal Caribbean	Freedom Class	160,000	3,600	Aker Yards	\$720	Summer
Celebrity	Celebrity Solstice	118,000	2,850	Meyer Werft	\$750	Fall
2009						
AIDA	TBD	68,500	2,030	Meyer Werft	\$315	April
MSC	Serenata	133,500	3,887	Chantiers de l'Atlantique	\$550	Spring
Celebrity	Celebrity Equinox	118,000	2,850	Meyer Werft	\$750	Summer
Royal Caribbean	Genesis Project	220,000	5,400	Aker Yards	\$1,000	Fall
Source: http://www.cruiseserver.net/travelpage/other/new_build.asp (accessed 3/21/2006)						

CHAPTER 3 | RISKS FROM POTENTIAL PORT MODIFICATIONS, CRUISE SHIPS AND ASSOCIATED ACTIVITIES TO SENSITIVE MARINE ECOSYSTEMS

3.1 ENVIRONMENTAL ISSUES AND RISKS

Different cruise ship scenarios (including the "status quo") encompass a 'package' of different environmental risk factors. Most of these can be linked, directly or indirectly, to physical infrastructures, operations and activities, of which the following are seen as particularly important:

- the type and number of cruise ships permitted in Bermuda, as well as the frequency of movements in and out of Bermuda's ports;
- creation or modification of ports, infrastructures and other shore facilities to accommodate the cruise ships;
- movement of cruise ships to and from Bermuda;
- dredging, channel widening/deepening/creation and other environmental alterations to facilitate navigation and ensure safe passage;
- transport of passengers to and from cruise ships, as well as movement of them around Bermuda by land or sea transport.

3.2 MAJOR ENVIRONMENTAL IMPACTS

Environmental risk is not only the likelihood of a particular event happening (e.g. of a post-Panamax ship striking a coral reef or another vessel), but also the severity of the event should it occur (e.g., impacts and recovery time from mechanical and chemical damage).²⁰ Actual or potential environmental impacts associated with different cruise ship options (infrastructures, operations and associated activities etc.) are briefly discussed below (see also section 3.3). The ecosystems and other natural assets at stake have been considered earlier (see section 1.3.1). The geographic locations of some but not all of these are known (Anderson et al., 2001). This information can help pinpoint which areas and assets may be at greatest risk.

Any given environmental impact, such as sedimentation, is likely to arise from several different activities (e.g. infilling for dockside and infrastructures, ship movement/propeller action, channel dredging). Similarly, a single action (e.g. widening

²⁰ In particular from antifouling paint on the ship's underside, but also potential impact from oil or other toxic cargoes in the event of a cruise ship colliding with a ship carrying hazardous materials.

of Town Cut at St George's) will lead to multiple environmental consequences. In all evaluations, it will be important to determine the direct and indirect incremental damage from post-Panamax ships, larger Panamax ships, and the smaller cruise ships currently responsible for transporting most of Bermuda's cruise passengers.

3.2.1 Coastal infilling for ports and other infrastructures

Loss of often highly productive shallow-water marine ecosystems and services is a major environmental concern (Price et al., 1998; Viers, 2000; Al-Ghadban & Price, 2002). Infilling and reclamation is a major cause of this. Even small bays (< 500 km²) can have a multi-million dollar value, for example through food chains leading to valuable seafood species. Dredging and infilling for new jetties, harbours or other infrastructures can easily reduce an ecosystem's bio-economic value, and also foreclose future resource-use options. More specific impacts of dredging and land reclamation include the following (Al-Ghadban & Price, 2002):

- damage to coral reefs, mangroves and seagrass beds, which may be important spawning grounds and/or nursery grounds;
- damage to the substrate on which fish live; removal or alteration of the benthos, which form the main source of food for many commercial fish species;
- increased turbidity locally, irritating or clogging fish gills, interfering with visual feeding and photosynthesis;
- increase in siltation, alteration of the character of sediments in and around spawning grounds and interference with egg development;
- potential loss or damage to fishing gears; erosion of value of properties fronting the coast and sometimes limited public access to shore.

Infilling and other forms of habitat degradation is one of the most significant environmental threats in Bermuda: 13.7% of the island is now covered with concrete (Anderson et al., 2001). Construction of Bermuda's airport in the 1940s greatly altered the ecology of the coral reefs, largely through increased sediment loadings (Knap et al., 2000). The dominant species changed from brain coral (*Diploria strigosa*) to finger coral (*Porites*). In total, 24 ha of coral reef, 18 ha of seagrass beds and more than 5 ha of mangroves were destroyed (Anderson et al., 2001).

The impacts of infill and other solid structures that would be needed to create new or modified piers at Dockyard, St Georges and Hamilton have not been quantified. Development of any new shore facilities (e.g. yacht marina) would also require some infill, as would a new container dock if it is moved from its current location in Hamilton. Infilling and reclamation often go hand-in-hand with dredging and sedimentation (below) and create similar impacts.

3.2.2 Dredging and sedimentation

Dredging causes major local and downstream environmental impacts. For example, habitat loss or degradation occurs at both the dredging site and at the location where sediment is eventually deposited (e.g. as landfill for port construction/reclamation). Ecological impacts of sedimentation elsewhere are well documented (e.g. Al-Ghadban & Price, 2002). Corals and other photosynthetic communities are particularly vulnerable. Documented impacts of sedimentation on corals include lower growth rates, reduced productivity and reduced recruitment. A detailed study on the Great Barrier Reef has shown that effects of sedimentation varies with morphologically different species of corals, sedimentation rates, turbidity, quantity, size and composition of sediment, as well as its nutrient and bacterial loadings (Stafford-Smith, 1992). Chronic sedimentation can cause total or partial mortality or bleaching depending on the response of corals.

In Bermuda, heavy siltation accompanied habitat degradation during construction of the airport. Fine silt material spread over the whole of St George's and Castle Harbours, impacting coral and permanently altering the marine environment. This has been the main reason why reefs in Castle Harbour may not return to their pre-1940s condition (Anderson et al., 2001). Cruise ships are major causes of sedimentation, plumes of which may extend considerable distances (Anderson et al., 2001, Plate 15). However, sedimentation in Bermuda arises naturally, in particular during storms and hurricanes, as well as from ships and other human activities. Their relative contribution is unknown, as is the influence of post-Panamax and large Panamax ships in comparison with smaller cruise ships.

This serious gap in knowledge is expected to be at least partly filled through forthcoming research by the Bermuda Biological Station for Research. It is of significance that storms occur principally in winter, when corals are relatively 'inactive'. In contrast, coral growth and reproduction are greatest during summer months. This coincides with the tourist season and when sedimentation from cruise ships is maximal. Reef corals of Bermuda are relatively slow-growing (Knap et al., 2000). Hence, recovery might be expected to be correspondingly slow following environmental impact.

Besides ecological impacts, physical environmental effects, positive and negative, accompany dredging. There can be both initial/capital and recurrent costs associated with these impacts. In Bermuda, it is understood that dredged sediments that are contaminated are shipped overseas.

3.2.3 Sewage pollution

Sewage disposal has both health implications (e.g. freshwater and seawater contamination), and environmental consequences (e.g. eutrophication), particularly for shallow lagoons and coral reefs. In areas with porous rocks and thin soils, nutrients from septic leach can be rapidly washed into the sea. Where piped sewerage is employed, sewage is often discharged untreated, although overt effects of discharge onto reefs are typically apparent only very close to outfalls. Background nutrient enrichment is recognised as an important cause of reef degradation worldwide (see Price et al., 1998). Nutrient enrichment encourages algal overgrowth of corals and can help transform

actively growing reefs into eroding ones. Risk et al. (1994; cited in Price et al., 1998) report lower coral cover and diversity, and higher numbers of certain associates, in sites at where sewage is the likely cause of stress.

Sewage treatment and pollution is a serious environmental issue in Bermuda. Some of the larger hotels in Hamilton and St George's discharge the effluent directly through ocean outfalls inshore of the outer reef line (Anderson et al., 2001). Most sewage enters bore holes where biological and chemical processes degrade it primarily into nutrients.²¹ The full extent to which sewage contaminates aquifers and the marine environment of Bermuda is unknown. However, there are at least two sewage 'hotspot' outfalls, one in Hungry Bay adjacent to Hamilton. An unmonitored sewage outfall also occurs in Tobacco Bay (north of St George's) and probably also at other localities.

Of particular significance is that during the tourism season cruise ships account for 40% of Bermuda's total sewage output per day. Currently Dockyard is the only cruise ship port with tertiary sewage treatment. In contrast to the smaller cruise ships responsible for the majority of Bermuda calls, newer ships often have on-board tertiary sewage treatment as well as increased waste storage capacities that potentially limit their need for shore-based treatment facilities. This would potentially reduce pressure on Bermuda's waste facilities, which are already over-stretched.

3.2.4 Ship-groundings

Ship groundings on coral reefs cause physical often long-lived impacts with adverse ecological effects. Jaap (2000) states that: "Often the grounded vessel will have crushed the reef, excavating sediments and rubble that end up as a berm of material behind the ship's resting position. Dealing with massive amounts of rubble debris is challenging. The options include leaving it in place and stabilizing it with cements; moving it a long way from the site and dumping it in deep water; or reconfiguring it by moving it off reef and building piles where it can do no harm." Sometimes blasting is necessary to free the grounded vessel, a practice which itself is very environmentally destructive.

A further point is that in Bermuda local resources would probably be insufficient for freeing a post-Panamax ship (and possibly even a smaller cruise ship) should an accident occur. Clearly impact would be greater from a large ship than a smaller one. The long-lasting impact caused by the 'Mari Boeing' off Bermuda has already been mentioned.

Chemical contamination from antifouling paints also represents a very serious potential environmental threat. When a ship hits a coral reef, the action of the hull scraping over a reef leaves significant quantities of antifouling residues on corals. Even the new generation of antifouling paints ('booster biocides', such as Irgarol 1051) are highly toxic to corals at minute (ng/l) concentrations.²² Such concentrations are reported in many

²¹ Although nutrients are not a human health issue, high concentrations are extremely damaging to reef corals.

²² Fifty percent of commercially available herbicides act on the Photosystem II (Jones, 2005). Impact arises partly from chlorophyll-mediated photo-damage, and shortage of reduced nicotinamide-adenine dinucleotide phosphate (NADPH), which is essential for CO₂ reduction (Jones, 2005).

harbours around the world including Bermuda. For example, Irgarol 1051 concentrations of up to 590 ng/l have already been reported in Hamilton (Connelly et al., 2001). Jones (2005) provides a recent review on the effects of herbicides on coral reefs. Following a recent ship-grounding in Australia it took 6 months to clear and clean the site of contaminated sediments.

It is unclear whether a post-Panamax ship is more or less likely than a smaller cruise ship to strike a coral reef (or some other major obstruction). Arguably, their highly sophisticated navigational equipment to facilitate safe passage might be partly offset by the sheer size of these ships relative to the channels they are navigating and the ‘windage’ created by the high sides of their hulls, in comparison with smaller cruise ships. It is understood that the wetted surface of all the ships and small craft in Bermuda (4,000-4,500 vessels) is equivalent to less than the area of the wetted surface of just two large cruise ships.

3.2.5 Other threats

A number of other environmental impacts may also arise (often indirectly) from the cruise ship industry. Effects are likely to increase if the industry expands. However, many of these threats are not confined to the cruise ship industry, but arise from wide-ranging human activities (Anderson et al., 2001). Examples include, but are not limited to, the following: invasive species, solid wastes, oil pollution and other contaminants.

3.3 IDENTIFYING TRADEOFFS LINKED TO ALTERNATIVE CRUISE SHIP OPTIONS

As mentioned, environmental implications can vary among cruise ship alternatives. Examples are given below in order to illustrate some of the tradeoffs that might be expected, to help guide the decision-making process. For example, one cruise ship option may be preferable, environmentally, to another in some ways but not in others. In reality tradeoffs are complex, as they involve environmental, economic and social interactions (McGlade & Price, 1993). Even the environmentally ‘perfect’ cruise ship (if it existed) could be undesirable to passengers or on other grounds, and therefore not put into operation for a particular destination.²³

3.3.1 Ports and cruise ships

Modifications to ports, potentially including infilling, waterfront construction, and/or dredging can lead to a variety of adverse environmental impacts. However, to the extent modifications are needed to facilitate port use by newer cruise ships, environmental benefits can arise. Amongst these are the decreased reliance such ships often have on shore-based facilities for obtaining fresh water, treating sewage, and storing/disposing of solid waste compared to the smaller, older ships currently responsible for the majority of

²³ For example, during our mission several individuals advocated cruise ships anchoring off St George’s or other parts of the coast of Bermuda, in line with this practice in other parts of the world. While this may avoid sedimentation and other adverse environmental effects within Bermuda’s inner reefs, bays, lagoons, ports and harbours (e.g. St Georges, Hamilton), it may not be a satisfactory solution in the eyes of tourists that may prefer cruise ship docking, for immediate access to the shore and associated facilities.

Bermuda cruise visits. In addition, Bermuda's ports have different capacities and capabilities for addressing the potential water and waste handling needs of cruise ships.

3.3.2 Navigational channels and cruise ship movements

Accessing Dockyard and Hamilton ports requires cruise ships to transit relatively long channels flanked in many places by coral, seagrass and potentially other sensitive habitats. St George's port requires a shorter channel transit, perhaps reducing the potential for adverse impacts. However, modifications to Town Cut would be required to provide access for larger ships that can already be accommodated in Hamilton and Dockyard. Such modifications may have severe environmental consequences. Besides some loss of reef and potentially terrestrial habitats/biota, the likely effects include: (1) channel and inner bay more open to storm surge and increased wave height; (2) other undesirable downstream effects (e.g. erosion & deposition) possibly requiring periodic sand replenishment and/or dredging; (3) adverse biological effects of sedimentation on corals, seagrasses and algal systems; (4) pollution impacts from suspension of sediments and increased bioavailability, plus removal and transport of contaminated sediments.

3.3.3 Tourist transport within Bermuda

Some cruise ships currently make stops at multiple ports within Bermuda. Such an approach is likely to reduce land-based transport requirements, but leads to more channel transits and associated risks. Water taxis have been introduced into Bermuda's transport system, and can reduce land-based transport demands and limit the need for cruise ships to move between ports. However, water taxis are not risk-free and may result in increased erosion, sedimentation and/or other impacts.

CHAPTER 4 | CARRYING CAPACITY, TOURISM AND BERMUDA

4.1 CARRYING CAPACITY, TOURISM AND BERMUDA

“Carrying capacity” can generally be defined as the amount of an activity or population that can be supported in a sustainable manner. While the concept is straightforward, developing quantitative estimates of carrying capacity is not. Current Bermuda policy allows a daily maximum of 10,000 cruise visitors. The underlying basis for this limit is unclear. Is it reasonable? Too high? Too low?

Published research on the topic of carrying capacity in a tourism context provides little guidance with respect to estimating capacity limits. Capacity measures frequently used in the literature include the “penetration ratio” (the annual number of tourist-days divided by resident-days) and the “density ratio” (the annual number of tourist-days divided by the total land area of the destination) (Thomas et al., 2005). As general background, Exhibit 4-1 presents penetration and density ratio measurements for Bermuda and 20 Caribbean islands, using 1999 and 2000 data.

For our purposes, the relative ranking of the islands is of more interest than the ratio values themselves. With respect to the penetration ratio, Bermuda ranks 7th of the 21 islands. This suggests that the number of tourists visiting Bermuda relative to the number of residents is above average, but not unusually high. However, Bermuda ranks 1st in terms of the density ratio. In other words, there are more tourists-days spent on Bermuda per square kilometer of land area than any of the other 20 islands examined (based on 2000 data).

To obtain a tourist density ratio equal to the median of the islands examined, Bermuda would have to reduce its number of tourist-days tremendously, by approximately a factor of 10 (based on 2000 data). However, there is no conceptual basis for estimating a specific density ratio associated with sustainability. Stated another way, the density ratio itself can not tell us if all, some, or none of the islands listed in Exhibit 4-1 are within sustainability limits. Nevertheless, Bermuda's density ratio is a cause for concern, as Bermuda appears to face more visitor “pressure” per square kilometer than all of the other islands examined.

Estimation of carrying capacity for cruise and other visitors is difficult for several reasons. First, the term “carrying capacity” can have a connotation of “minimum” resource levels required to sustain society and the environment, but stakeholders often choose to limit impacts well before they reduce resources to these “minimum” levels. For this reason, many researchers prefer to think in terms of “limits of acceptable change” rather than “carrying capacity” (e.g., Hawkins et al., 2005). This does not imply that adverse impacts must be accepted: it is possible that stakeholders may determine that the

amount of “acceptable change” for specified resources is low, zero, or even negative (i.e., adverse impacts already are beyond acceptable levels).

In addition, visitor pressure on island resources needs to be considered in light of "baseline" pressure exerted by island residents. Further, for some resources (e.g., food production), "unsustainably low" local capacity easily can be addressed through purchase off-island in well-established markets or other means (e.g., building desalinization plants to meet fresh water requirements). Finally, to the extent visitor-related limits on impacts are established, allowable visits need to be allocated among different types of visitors (e.g., cruise tourists, air-arrival tourists and those traveling for business purposes).

In our view, evaluation of the current cruise visitor policy (i.e., no more than 10,000 visitors per day) or proposed alternatives needs to begin with a clear identification of the type and magnitude of incremental environmental and social impacts associated with the specified level of cruise visits and the approach for accommodating them.

For example, if 10,000 daily visits were expected to be generated through the presence of one relatively small cruise ship in St. George's, two in Hamilton and a single, larger Panamax or post-Panamax ship at Dockyard, associated impacts may include (but not necessarily be limited to):

- sedimentation of coral and/or other sensitive near-channel habitats attributable to cruise ship passage;
- incremental risk of vessel groundings and/or spills associated with the number of cruise ship trips needed to generate 10,000 daily visits;
- impacts associated with potentially different fresh water, sewage and solid waste demands on each port;
- noise and emissions increases associated with incremental land-based transport of cruise visitors once on-island;
- sedimentation, erosion and/or emissions associated with incremental water taxi transport associated with cruise visitors;
- traffic congestion attributable to cruise visitors (arising from large numbers of visitors arriving at the same time and generally seeking transport to a limited set of destinations);
- crowding and/or environmental impacts arising from recreational use of island resources; and
- other impacts of concern to residents (e.g., impaired views of Hamilton Harbor when cruise ships are present).

The inventory of potential impacts may be different under alternative capacity limits and/or alternative means of achieving that capacity. For example, proposals to achieve a specified visitor capacity through (in part) widening of Town Cut would raise additional issues associated with potential hydrodynamic changes affecting the harbor. As noted in Chapter 5 of this document, the likely significance of some of these potential impacts is

uncertain due to a lack of relevant data. Implementation of selected research projects identified in Chapter 5 may help address key uncertainties.

Based on information describing the type and magnitude of potential impacts, stakeholders should first determine whether any clearly raise sustainability concerns. For example, if some aspect of the cruise visitor strategy results in adverse impacts to critical habitat for endangered endemic species, stakeholders might agree that modifications need to be made to the strategy (e.g., through changes in cruise ship channel transit speeds, water taxi routes, engineered structures to protect habitats, etc.) and/or appropriate reductions made to proposed visitor limits.

Assuming any sustainability "deal-breakers" can be addressed, stakeholders need to consider whether identified impacts are "acceptable." To inform this evaluation, stakeholders should be provided with estimates of the incremental monetary benefits and incremental costs associated with proposed cruise visits. While estimates of incremental revenues are publicly available, incremental cost data are more difficult to obtain. For example, what is the annual cost to staff and maintain cruise-related port infrastructure? Are water taxi and/or bus costs subsidized by the government? This latter issue can be complex: if cruise visitors help fill water taxis and buses that are underutilized but commonly used by residents, the effect may be beneficial. On the other hand, some bus and/or water taxi itineraries may be little-used by residents. Extra buses and/or water taxis may need to be added on popular routes to accommodate cruise-related demand surge. Any such incremental costs not recovered by fares will offset revenues generated by cruise ships.

For new development proposals, incremental costs will include cruise-related infrastructure improvements. What is a reasonable amortization schedule for any such costs (including future maintenance requirements) that will be incurred by Bermuda, in light of expectations regarding useful life?

Detailed evaluation of the sustainability of current limits on cruise visitors (and ports, infrastructure and vessels relied on to generate current cruise visits) and/or proposed alternatives will require a level of effort beyond that available for this analysis. In addition, such an evaluation would benefit from the implementation of further research identified in Chapter 5 to address key uncertainties regarding the potential magnitude of adverse environmental /social impacts and monetary benefits and costs.

Nevertheless, with respect to current cruise visitation limits, our preliminary review of readily available information raises several specific issues/questions:

- It is our understanding that the relatively small cruise ships calling on Hamilton and St. George's often rely on these ports to handle their sewage. Sewage treatment capabilities are limited at these ports (maceration at Hamilton, primary treatment at St. George's). However, the potential magnitude of incremental environmental impacts are difficult to estimate, given the limited study of "baseline" impacts associated with the management of resident-generated sewage. This issue appears less significant for Dockyard, which has or will soon

have tertiary treatment capabilities and accepts calls from larger, newer vessels that generally have more advanced on-ship treatment systems;

- It is our understanding that the smaller cruise ships often require fresh water from the ports. The extent to which this incremental demand raises any significant concerns is unclear. Regardless, this issue likely is less significant for Dockyard, as it has or will have relatively large water storage capacity that allows it to better manage water demand, and the newer ships that tend to call on it appear to rely less on destination ports for fresh water;
- The potential magnitude of sedimentation-related impacts on coral and/or other sensitive habitats near ship channels and port harbors used by cruise ships is unknown;
- The potential magnitude of sedimentation and/or erosional impacts from water taxis is unknown;
- While anecdotal information suggests that cruise ship arrivals contribute to traffic congestion, quantitative estimates of increases in travel times are not available;
- While cruise visitor use of recreational and cultural resources can lead to crowding, it may be difficult to adjust cruise visitor limits based on such factors. First, for resource use that is fee-based, overcrowding potentially can be addressed by raising fees for non-residents and/or establishing limits on daily visitation. Second, cruise visitation is highest mid-week, rather than on weekends that potentially would create more conflicts with resident use. Third, recreational activities associated with sensitive habitats (e.g., diving at coral reefs) do not appear to occur in a volume sufficient to raise sustainability concerns (e.g., 5,000 to 6,000 dives/site/year proposed as a sustainable carrying capacity by Dixon et al., 1993 and Hawkins & Roberts, 1997);
- We have not attempted to evaluate the magnitude of incremental revenues and costs generated by current cruise ship visitation levels.

EXHIBIT 4-1 PENETRATION AND DENSITY RATIO COMPARISONS

COUNTRY	LAND AREA (SQUARE METERS)	INDIGENOUS POPULATION MID-YEAR 2000	NUMBER OF ANNUAL TOURIST ARRIVALS IN 2000	AVERAGE LENGTH OF STAY IN 2000 (NIGHTS)	PENETRATION RATIO (PR)*	PR RANK	DENSITY RATIO (DR)**	DR RANK
Bermuda	53	62,600 (1999)	328,305	6	.0862	7	102	1
Anguilla	91	12,900	43,789	8.6	.0800	9	11	9
Aruba	188	95,200 (1999)	721,224	7.7	.1598	2	81	2
Bahamas	13,864	305,000	1,596,160	6.5	.0932	6	2	20
Barbados	432	267,500	544,696	7.3	.0407	13	25	4
Bonaire	288	13,500	51,269	9.3	.0968	5	5	15
British Virgin Islands	150	19,900 (1999)	281,119	9.13	.3534	1	47	3
Cayman Islands	260	39,200	354,087	6.4 (1998)	.1584	3	24	5
Curacao	444	138,300	191,246	8.2	.0311	14	10	10
Dominica	750	78,120 (1999)	69,578	9.2 (1999)	.0224	16	2	19
Dominican Republic	48,442	8,364,000 (1999)	2,972,552	10	.0097	20	2	21
Grenada	344	101,700	128,864	7.2	.0250	15	7	11
Guadeloupe	1,373	422,500 (1999)	623,134	5.2	.0210	17	6	13
Jamaica	11,424	2,597,600	1,322,690	10.1	.0141	19	3	17
Martinique	1,060	381,400	526,290	13.2	.0499	11	18	6
Montserrat	102	5,270	10,337	14.3 (1999)	.0768	10	4	16
Puerto Rico	9,065	3,866,000 (1999)	3,341.4	2.5	.0059	21	3	18
St. Kitts & Nevis	269	40,400	73,149	16.4	.0814	8	12	7
St. Lucia	616	156,000	269,850	9.6	.0455	12	12	8
St. Vincent and the Grenadines	389	112,000 (1999)	72,895	10.0	.0178	18	5	14
Turks and Caicos Islands	417	24,000 (1999)	151,372	7.4	.1279	4	7	12

NOTES:

Source: Caribbean Tourism Organization. 2002. Caribbean Tourism Statistical Report 2000-2001 Edition. *pages 109 - 240.*

* Penetration Ratio (PR) calculated as: $\frac{\text{Average length of stay} \times \# \text{ Tourists annually}}{365 \times \text{Indigenous Population}}$

** Density Ration (DR) Calculated as: $\frac{\text{Average length of stay} \times \# \text{ Tourists annually}}{365 \times \text{Area in square kilometers}}$

CHAPTER 5 | NEXT STEPS

5.1 PLANNING ISSUES AND PROCESS IN BERMUDA

To date, several different conceptual visions for port development in Bermuda have been made public by a variety of stakeholders. To our knowledge, no public process has been established for reconciling potentially different visions over an appropriate time frame. In our view creating such a process is critical, as it allows for the timely introduction and consideration of relevant information describing benefits, costs and risks and increases the likelihood of achieving an integrated, rational, island-wide planning outcome that avoids the host of adverse consequences that can result from a more fractured, localized development process.

Experience elsewhere has shown that this objective often can effectively be accomplished through an integrated coastal management (ICM) process, defined as "a continuous and dynamic process that unites government and the community, science and management, sectoral and public interests in preparing and implementing an integrated plan for the protection and development of coastal systems and resources" (GESAMP, 1996).

Several frameworks are commonly used to facilitate the ICM process, many of which have elements shown in Annex 1. This can be helpful for identification of many different coastal problems, opportunities and solutions. It may have application in Bermuda.

5.2 ADDITIONAL RESEARCH NEEDS

Based on our preliminary review of readily available information, we have several practical suggestions for additional research that would help resolve uncertainties concerning potential impacts and risks associated with cruise ship development alternatives. In many instances our suggestions build on existing research already underway and/or could be cost-effectively assembled from the substantial but somewhat dispersed information available in various existing documents and analyses. In addition, we expect that in many cases Bermuda-based experts could perform described work. The priorities attached to individual projects will depend on several factors, including the development concepts that are pursued most actively, the timing of any public process for reconciling different development concepts, and available funding. Brief summaries of our suggestions, in no particular order, are provided below.

- Sedimentation Caused by Cruise Ships - It is our understanding that the Bermuda Biological Station (Dr. Ross Jones) will initiate a study on this topic in the next few months. If Dr. Jones is amenable, we would suggest near-term, brief discussions to assess whether additional funding and/or other assistance might provide cost-effective improvements to the data generated. For example, how

many cruise ship transit events will be monitored? In which channels? Is the timing and duration of the study sufficient to capture impacts from a broad array of cruise ships? Will efforts be made to obtain ship speeds associated with each event? How will sedimentation be measured? To what extent is there a means for linking observed sedimentation to ecological effects? The intent of our suggestion is only to maximize the utility of information generated by this unique opportunity to study this important issue.

- Preliminary Evaluation of Expected Hydrodynamic Changes Arising from Modifications to Town Cut, Two Rocks Passage and/or Other Navigational Channels - To the extent that development concepts are pursued that involve such modifications, associated impacts can be long-lasting and severe and need to be carefully evaluated. The first step towards understanding potential impacts is to perform a preliminary evaluation of how proposed modifications may affect the movement of water and sediment in associated harbors and other affected areas under "normal" as well as severe weather conditions.
- Sharing of Results and Information from the Government's Cruise Ship-Specific Navigational Safety Computer Simulations - One important environmental and human health risk associated with cruise ships is the risk of ship groundings. This type of low probability/high impact event is difficult to forecast, and every ship faces risks due to operator error, systems failures, weather conditions and similar factors. Nevertheless, it is our understanding that the government runs computer simulations prior to granting approvals for cruise ships to call on any of Bermuda's ports. To the extent that stakeholders can be provided with information about the parameters used to determine acceptable safety margins and the results of ship-specific simulations, it might provide useful insights into the relative grounding risks associated with ships with different characteristics (e.g., size, sail area, maneuvering systems, desired speed, etc.).
- Identification of Biodiversity and Sensitive Coastal Habitats Potentially Affected by Cruise Ships and Cruise Ship Development – It is important to know where seagrass beds, mangroves, coral, fishery nursery areas, and other important habitats are located in relation to channels utilized by cruise ships and related infrastructure. Substantial information already exists on this topic, although to our knowledge it has not been integrated into a single GIS-based application. Integration of such information will facilitate evaluation of relative risks associated with different development concepts. It is our understanding that Mr. Thad Murdoch already is assembling related information on seagrass beds and corals.
- Documentation of Current Capabilities and Expected Near Term Improvements in Fresh Water Storage, Sewage Treatment, and Solid Waste Handling at Dockyard, Hamilton and St. George's - While information already exists on this topic, we have been unable to find a single document that identifies current capabilities and improvements that will be completed in the next one or two years. While cruise ships vary in their reliance on shore-based facilities and internal methods and capacities for addressing fresh water, sewage and solid waste needs, important

differences exist between Bermuda's ports in their ability to handle them. These differences should be documented and considered by stakeholders in their evaluation of different port development concepts.

- Potential Adverse Impacts/Risks of Water Taxis - By moving people over water rather than adding to already congested land-based transport, water taxis provide a variety of benefits. However, their potential adverse impacts are poorly studied and should be evaluated. For example, frequent taxi trips may contribute to shoreline erosion and/or adversely affect nearby, sensitive ecological areas. While reducing land-based transport reduces associated human health risks, boat transport is not risk-free. Water taxis may be an important component of current and future development alternatives, but associated impacts may not be trivial and should be understood (and perhaps mitigated through speed limits, selection of transport routes, engineering solutions, or other options).
- Preliminary Identification of Borrow Areas for Fill and Impact Analysis - To the extent that development concepts are pursued that involve land reclamation in port harbors, in approximate terms how much of what type of fill material will be needed? Where is this material expected to come from? What impacts are likely at source areas? While detailed evaluation of such issues may be premature at this stage, stakeholders should have a general understanding of the expected type, amount and source of fill and potential impacts.
- Preliminary Identification of Areas and Approximate Quantities to be Dredged - To the extent that development concepts are pursued that involve dredging, where is dredging likely to take place? In approximate terms, how much material might need to be dredged? How will hazardous dredge material be disposed of or otherwise managed? Preliminary information on these issues should be made available to stakeholders at the conceptual design stage, to help assess likely tradeoffs between development alternatives.
- Study of Increased Traffic Congestion/Travel Time Currently Attributable to Cruise Visitors – Cruise ships create surges in land-based transport use that can tax Bermuda's already limited land-based transport capacity. By collecting traffic congestion/transport time data at key locations, on days with differing levels of cruise ship visitation, stakeholders will better understand the incremental effects of cruise ships on travel time.
- Evaluation of Incremental Revenues and Costs Generated by Cruise Ship Visitors – As discussed in Chapter 4, it is important for stakeholders to understand the net monetary gain accruing to Bermuda from cruise ship visitation. While estimates of cruise-related revenues have been made public, it may be useful to have an independent review performed. To the extent incremental costs are less well documented, they can be estimated. Such an evaluation could be extended to visitors arriving by air, as well as business travelers, to help stakeholders understand tradeoffs between different types of visitors.

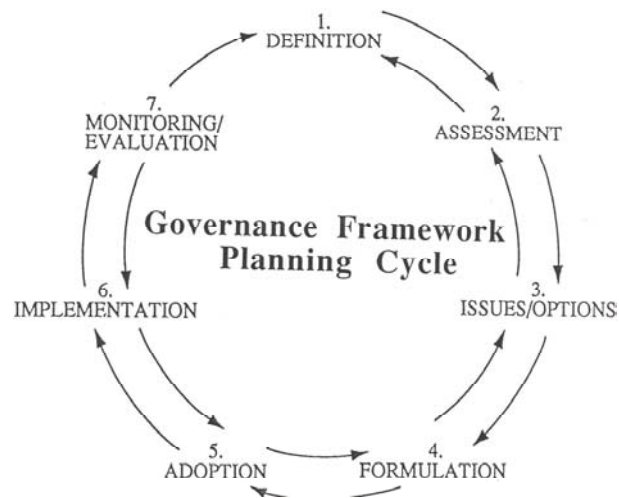
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ANNEX 1

**INTEGRATED COASTAL MANAGEMENT (ICM) CYCLE AND STAGES
(FROM PERNETTA & ELDER, 1993 AND OTHER SOURCES).****(A) ICM (OR GOVERNANCE PLANNING) CYCLE**

(B) ICM STAGES

1. PROBLEM DEFINITION (OBJECTIVES)

Here the objectives and scope of the problem or strategy are identified. Clearly, the objectives defined and agreed determine all future steps of the decision-making process including subsequent actions.

2. ASSESSMENT (DATA COLLECTION AND COMPILATION)

This entails collection of data on aspects of the biodiversity, the environment and also human, legal, socio-political and related issues. This can be acquired using available information, and/or data from field surveys, interviews and other sources. Geographical Information System (GIS) allows periodic updating of information. This phase does not involve data analysis or interpretation (see below), without which data and databases are of only limited value.

3. ISSUES AND OPTIONS (DATA ANALYSIS)

This concerns data analysis, to define and quantify actual or potential problems, opportunities and other issues, in this context relating to biodiversity conservation. Issues, problems and opportunities can be identified in different ways such as: (i) map analysis, including use of GIS, for instance to identify areas of resource-use conflict and compatibility; (ii) statistics, modelling and other numerical analyses, for example fishery stock assessment, or determining the effects of sewage on coral reefs and reef fisheries; (iii) issue analysis, to help understand problems such as common resource property rights, or assessment of institutional capabilities; (iv) integrated analysis (i - iii), for example to determine expected costs, impacts, benefits and options concerning a proposed tourist resort. Innovative software systems are currently under development to undertake complex analyses such as these and to facilitate coastal management in other ways.

4. FORMULATION (DATA SYNTHESIS)

This involves data synthesis, using the results of the preceding two phases, to formulate an action plan, strategy or any other decision. These usually comprise a series of operational tasks. Tasks may be divided into those relating to the entire coast, country or region (i.e. broadscale) and those targeted at particular coastal areas (e.g. protected areas, habitat restoration).

5. ADOPTION

Legislation is normally required for adoption of a plan, or decision, although in certain situations voluntary action can occur.

6. IMPLEMENTATION

Once a strategy, plan or action has been adopted, or agreed upon, it needs to be implemented. Here practical considerations are important (e.g. human and physical resources), and collaborative support may be needed. This phase often includes the development and implementation of management plans (e.g. for coastal and marine protected areas).

7. MONITORING /EVALUATION /ENFORCEMENT

This includes assessing the effectiveness of the action plan, and components of it. As with EIA, comparison can be made between expected and actual results and adjustments to the plans made as necessary.